

**SEMICONDUCTOR SUBSTRATE,
SEMICONDUCTOR DEVICE, AND METHOD
OF PRODUCING SEMICONDUCTOR
SUBSTRATE**

TECHNICAL FIELD

[0001] The present invention relates to a semiconductor substrate, a semiconductor device and a method of producing a semiconductor substrate.

BACKGROUND ART

[0002] Conventionally, in the field of power electronics, a power MOSFET (Metal Oxide Semiconductor Field Effect Transistor) has been used as a switching element having a high-speed switching function. As a structure of a power MOSFET, a super junction structure can be exemplified.

[0003] In the super junction structure, an n-type layer and a p-type layer are alternately formed in a conductive layer that connects a source and a drain. In the super junction structure, a depletion layer is formed in an interface between the n-type layer and the p-type layer. Accordingly, between the source and the drain, an electric field is formed not only in a direction from the source to the drain, but also in a direction from the n-type layer to the p-type layer. As a result, the electric field between the source and the drain does not concentrate on a certain part in the conductive layer. Therefore, the super junction structure can provide high voltage resistance performance.

[0004] As a method of producing a semiconductor substrate used for forming the super junction structure, a method of forming a trench in an epitaxial layer and forming a plurality of epitaxial layers in the trench thus formed is proposed (for example, refer to Patent Documents 1 and 2).

[0005] [Patent Document 1] Japanese Unexamined Patent Application Publication No. 2005-294711

[0006] [Patent Document 2] Japanese Unexamined Patent Application Publication No. 2005-317905

DISCLOSURE OF THE INVENTION

Problems to be Solved by the Invention

[0007] However, in the method disclosed in Patent Documents 1 and 2, temperature is different in formation of each of the epitaxial layers, and thus concentration of dopant is different in each of the epitaxial layers. This may prevent obtaining desired electrical characteristics (for example, resistivity).

[0008] The present invention is aimed at providing a semiconductor substrate, a semiconductor device and a method of producing a semiconductor substrate that are more likely to provide desired electrical characteristics.

Means for Solving the Problems

[0009] In a first aspect of the present invention, a method of producing a semiconductor substrate includes: a first epitaxial layer forming step of forming a first epitaxial layer by introducing a dopant gas of a first conductivity type to a semiconductor substrate of the first conductivity type; a trench forming step of forming a trench in the first epitaxial layer; and an epitaxial layer forming step of forming an epitaxial layer of a second conductivity type that is different from the first conductivity type on the first epitaxial layer and in the trench so as to fill up the trench, using a plurality of growth

conditions including different growth rates, and making concentration of a dopant gas of the second conductivity type, which is incorporated into the epitaxial layer, constant in each of the plurality of growth conditions.

[0010] According to the second aspect of the present invention, in the method of producing a semiconductor substrate as described in the first aspect, it is preferable that the plurality of growth conditions includes growth temperature of the epitaxial layer; and the growth rate is changed by changing the growth temperature of the epitaxial layer.

[0011] According to the third aspect of the present invention, in the method of producing a semiconductor substrate as described in the first aspect, it is preferable that the plurality of growth conditions includes flow rate of the dopant gas of the second conductivity type that is introduced into the epitaxial layer and the trench; and the growth rate is changed by changing the flow rate of a material gas.

[0012] In a fourth aspect of the present invention, a method of producing a semiconductor substrate, includes: a first epitaxial layer forming step of forming a first epitaxial layer by introducing a dopant gas of a first conductivity type to a semiconductor substrate of the first conductivity type; a trench forming step of forming a trench in the first epitaxial layer; and a second epitaxial layer forming step of forming a second epitaxial layer on the first epitaxial layer and in the trench, by introducing a dopant gas of a second conductivity type that is different from the first conductivity type at a predetermined first dopant gas flow rate, in an atmosphere of a predetermined first temperature; a third epitaxial layer forming step of forming a third epitaxial layer to fill up the trench, by introducing the dopant gas of the second conductivity type to the second epitaxial layer at a second dopant gas flow rate that is greater than the first dopant gas flow rate, in an atmosphere of a second temperature that is lower than the first temperature; a fourth epitaxial layer forming step of forming a fourth epitaxial layer by introducing the dopant gas of the second conductivity type to the second epitaxial layer and the third epitaxial layer at a third dopant gas flow rate that is lower than the second dopant gas flow rate, in an atmosphere of a third temperature that is higher than the second temperature.

[0013] In a fifth aspect of the present invention, a method of producing a semiconductor substrate includes: a first epitaxial layer forming step of forming a first epitaxial layer by introducing a dopant gas of a first conductivity type to a semiconductor substrate of the first conductivity type; a trench forming step of forming a trench in the first epitaxial layer; and a second epitaxial layer forming step of forming a second epitaxial layer on the first epitaxial layer and in the trench, by introducing a dopant gas of a second conductivity type that is different from the first conductivity type at a predetermined first dopant gas flow rate, in an atmosphere of a predetermined first temperature; and a third epitaxial layer forming step of forming a third epitaxial layer to fill up the trench, by introducing the dopant gas of the second conductivity type to the second epitaxial layer at a second dopant gas flow rate that is greater than the first dopant gas flow rate, in an atmosphere of a second temperature that is lower than the first temperature.

[0014] In a sixth aspect of the present invention, a method of producing a semiconductor substrate includes: a first epitaxial layer forming step of forming a first epitaxial layer by introducing a dopant gas of a first conductivity type to a semiconductor substrate of the first conductivity type; a